

REMARKS

Claims 16-19 and 25 are pending in the application.

Support For Claim Amendments

Independent claims 16 and 17 have been amended to recite: --metal balls having a diameter of not greater than 150 micrometers--.

This amendment is supported in the specification at page 8, lines 20 to 21 (which reads " ... a solder ball 46 of Pb-Sn alloy having a diameter of 80 μm ... ") and page 9, lines 30-31 (which reads " ... a solder ball of Pb-Sn alloy having a diameter of 150 μm ... ").

Independent claims 16 and 17 have also been amended to recite: --adhesive bonding the metal balls to the electrodes with a flux without reflowing the metal balls, whereby the metal balls are only bonded to the electrodes with flux without reflowing--.

Page 6, lines 17-31 make clear that the metal balls are adhesive bonded to the electrodes and reflowing takes place at a later time when the semiconductor device of the present invention is flip chip bonded to a substrate.

New matter is not being presented by the present amendment.

§103

Claims 16-18, 20-22, 25 and 26 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,940,181 to Juskey, Jr. et al.

Claims 19, 23 and 24 were rejected under 35 U.S.C. §103(a) as being unpatentable over Juskey, Jr. et al. in view of Japan No. 4-65130 to Okuyama.

These rejections, as applied to the amended claims, are respectfully traversed.

Patentability

The present invention relates to a process for producing a semiconductor device (chip) to be mounted on a substrate by flip-chip bonding, the substrate being commonly called an "interposer", and being subsequently mounted on a circuit board (insulation substrate), such as a printed circuit board, as illustrated in attached Fig. A. The invention is particularly directed to the bonding of metal balls onto a chip. The metal balls are adhesive bonded to the electrodes of the chip with flux without reflowing. At a later time, during the mounting of the chip on a substrate, the metal balls are reflowed to form bumps.

Juskey relates to the bonding of a "solder bumped member" to a substrate. The "solder bumped member" in Juskey is a solder bumped chip carrier 28 (column 3, line 27), which means a carrier having a chip mounted thereon and represents the interposer shown in Fig. A. The "substrate" in Juskey is a circuit carrying substrate 10 (column 3, line 28), such as a printed circuit (PC) board (column 1, lines 38 to 39). The solder bump chip carrier of Juskey is mounted on the circuit carrying substrate (column 3, lines 43-44).

As illustrated in Fig. A, the metal balls (or bumps) on a chip of the present invention have a smaller size compared to the size of the bumps of a solder bumped member (interposer) in Juskey. For example, the metal balls bonded to a chip according to the process of the present invention have a diameter of 150 micrometers or smaller, whereas the bumps with which a solder bumped member in Juskey is provided have a diameter of 34 mils (864 micrometers) (column 3, lines 9 to 10).

In Juskey, the bumps 30, which are not spherical metal balls as in the present invention, are provided on the chip carrier 28 to be subsequently mounted on the substrate 10, and flux 26 is provided on the substrate 10 before the bonding of the chip carrier 28 thereto. In contrast, in the present invention, the chip to be mounted on a substrate is provided with metal balls before the formation of bumps (bumps are formed from the metal balls during subsequent mounting of the chip on a substrate by reflowing), and the metal balls of the present invention are adhesive bonded to the electrodes of the chip with a flux.

Thus, Juskey does not disclose or suggest the process of the present invention for producing a semiconductor device having metal balls for the subsequent formation of bumps, having a diameter of 150 micrometer or smaller, which is much smaller than that of the bumps in Juskey, by adhesive bonding the metal balls of the present

invention to the electrode of the device per se with flux without reflowing.

It is therefore submitted that amended independent claims 16 and 17, and all claims dependent thereon, are patentable over Juskey.

In Okuyama, solder balls 8 for bump formation are fixed to an insulation substrate 2 through pads 6 and flux 23, as seen in Fig. 1, to provide a terminal resistance unit 1 (Fig. 12), in which bumps 4, 5 are formed on the insulation substrate, for the connection with external connecting terminals. Thus, the solder balls in Okuyama are provided on an insulation substrate, as shown in attached Fig. B-1, and are used for the bonding of resistor elements, as shown in attached Fig. B-2. The solder balls used in Okuyama have a diameter of 0.3 to 0.4 millimeter (page 2, the lower left column, lines 13 to 15, and the lower right column, lines 6 to 9). The unit as described in Okuyama has a relatively small number of terminals, and the bumps formed thereon are not needed to have a strictly controlled height.

In contrast, the present invention is directed to the bonding of metal balls onto a chip (semiconductor device), as described above. During the mounting of the chip provided with the metal balls, they are used for the internal connection in a semiconductor package, as seen in the right hand of attached Fig. A. The metal balls have a diameter of 150 millimeters or smaller. A semiconductor device has a much larger number (in some cases, several thousands) of

terminals (bumps) compared to a resistor, which has only two terminals. In such a semiconductor device, it is essential that the balls are formed with a high accuracy to have a strictly controlled height. As shown in attached Fig. C, when a chip having a large number of metal balls formed with a low height accuracy is flip-chip bonded to a substrate such as an interposer, variation in ball height results in defective junctions. Such a strict ball height accuracy is not required for the external connecting terminals in Okuyama. As such, none of the object, constitution, operation, and effect of the present invention is described or suggested in Okuyama.

Consequently, a person with ordinary skill in the art could not conceived of the present invention of the amended claims of the present application based on either Juskey or Okuyama or a combination of Juskey and Okuyama.

It is therefore submitted that independent claims 16 and 17, and claims 18 , 19 and 25 dependent thereon, are patentable over Juskey and/or Okuyama.


CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the present amendment be entered and the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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